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EFFECTIVENESS OF THREE INSECTICIDES APPLIED AT TWO DROPLET SIZES FOR CONTROL OF THE DOUGLAS-FIR TUSSOCK MOTH AND WESTERN SPRUCE BUDWORM

by

George P. Markin,[1] Harold O. Batzer,[2] and J. Wayne Brewer[3]

ABSTRACT

Carbaryl, trichlorfon, and acephate were evaluated at two different droplet sizes against laboratory raised Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough), and field populations of the western spruce budworm, *Choristoneura occidentalis* Freeman. Small droplets of carbaryl and trichlorfon caused higher mortality of both Douglas-fir tussock moth and western spruce budworm than did larger droplets. Small droplets of acephate gave a higher mortality of the western spruce budworm in the field but were less effective against the Douglas-fir tussock moth in laboratory bioassays.

[1]USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Davis, Calif. 95616.

[2]USDA Forest Service, North Central Forest Experiment Station, St. Paul, Minn. 55108.

[3]Department of Zoology and Entomology, Colorado State University, Ft. Collins, Colo. 80523.

REST SERVICE - U.S. DEPARTMENT OF AGRICULTURE - PORTLAND, OREGON

INTRODUCTION

In the western United States, two major forest defoliators are the Douglas-fir tussock moth, *Orgyia pseudotsugata*[4] (McDunnough), (Wickman 1963, Wickman et al. 1973) and the western spruce budworm, *Choristoneura occidentalis*[5] Freeman (Carolin and Honing 1972). Before 1973, the only extensively used control for these two pests was aerial applications of DDT. The U.S. Forest Service has undertaken an extensive research program to find alternate chemical insecticides. By 1975, field tests had indicated that three chemicals, carbaryl (SEVIN® 4 Oil),[6] trichlorfon (Dylox® 1.5 oil), and acephate (Orthene® 75S) were promising.

All earlier tests used boom-mounted conventional hydraulic pressure nozzles, and the question was raised as to whether other commerically available spray systems could effectively apply these materials. We were particularly interested in rotary atomizer systems, which are reported to increase the total number of droplets per given volume of spray, thus increasing their coverage of the treated area and their chance of contacting the target insect.

A series of tests was conducted in 1975 with the aforementioned insecticides, to compare a rotary atomizer system that produces a small droplet with a conventional hydraulic system that applies larger droplets for control of both the Douglas-fir tussock moth and the western spruce budworm.

MATERIALS AND METHODS

The spray plots were located in the Wenatchee National Forest on the east side of the Cascade Range approximately 32 km northwest of Ellensburg, Washington. Laboratory facilities for conducting the bioassay were at the Department of Biology, Central Washington State College at Ellensburg. Plots in a fir forest that contained an outbreak of budworm were treated, and population reduction was conventionally evaluated. Also, foliage samples were collected after treatment and brought into a laboratory where they were bioassayed by using laboratory reared tussock moth. A bioassay was necessary because, in 1975, no suitable outbreak populations of tussock moth existed.

Twenty-one rectangular plots, each about 6.5 ha in size and separated from each other by a minimum of 1 km, were selected for the test. In the center 1 ha of each plot, 15 open-grown trees, both Douglas-fir, *Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco, and grand fir, *Abies grandis* (Dougl.) Lindl., 9 to 18 m high were selected as sample trees.

Three of the 21 plots were randomly selected as untreated controls; the remaining plots were divided into three replicates of 6 plots, each at about the same elevation, giving a randomized block design. The assigning of a treatment to the six plots in each replicate was random. Treatment was made when 90 percent of the bud caps had fallen from the new growth of Douglas-fir.

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[4] Lepidoptera: Lymantriidae.

[5] Lepidoptera: Tortricidae.

[6] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

A Hiller 12E helicopter was used for applying all materials. Standard size spray droplets (referred to as large droplets) were applied with a 9.14-m boom equipped with Spraying Systems (Wheaton, Ill.) T8002 flat-fan nozzle tips. The small droplet size was obtained with five to eight spinning disc atomizers on a 5.49-m support boom. The atomizers were basically the modified version of the Bals Turbair spinning nozzle described by Boving et al. (1971).

Carbaryl (diluted 1:1 with diesel oil) was applied at the rate of 2.24 kg AI/9.35 liters per ha (2 lb AI/gal per acre). Trichlorfon was applied undiluted at 1.68 kg AI/ha (1.5 lb AI/acre). Acephate was applied at 1.12 kg AI/18.7 liters per ha (1 lb AI/2 gal per acre) in water. In mixing each of the formulations, 0.1 percent Rhodamine B dye was added to the finished spray solution to facilitate spray deposit assessment. The dye was first dissolved in oleic acid (2.5 percent of final spray solution) before mixing with trichlorfon and carbaryl.

Spray deposit was sampled from two aluminum plates and one white Kromekote card placed in an open area adjacent to each sample tree. The amount of spray deposit was determined by fluorescent methods (Yates and Akesson 1963). Deposit on the plates was converted to liters per hectare. The cards were used to determine volume median diameter (vmd)[7] and drop density with a Quantimet 720 (Imanco Image Analyzing Computer and Co., Monsey, N.Y.), which electronically counted and sized all spots formed by droplets larger than 20 μm.

Samples to be used for bioassay with tussock moth were collected 24 h before treatment and at 30 min (carbaryl and trichlorfon) or 24 h (acephate) after treatment. Three branch tips 30 to 40 cm long were collected from the midcrown of each tree; they were placed in a perforated plastic sack, the sack sealed around the stems, and the base of the branches placed in water. Ten third-instar, laboratory-reared tussock moths were introduced into each sack and allowed to feed for 7 days, after which the number of dead and living larvae was counted to determine percent mortality.

The sample procedure for the budworm was basically that described by Carolin and Coulter (1972); it consisted of counting the number of larvae and buds on two 40-cm branches removed from midcrown of each sample tree at prespray (24 h) sampling and four branches at three postspray sampling intervals (3, 7, and 14 days). The population was expressed as the number of budworm larvae per 100 buds.

Applications began on June 15 and were completed by June 19, 1975. Temperatures ranged from 0° to 17°C. Windspeeds were below 8 km/h and averaged 1-3 km/h. Two short rain showers late in the afternoons of June 18 (0.8 cm) and June 19 (0.5 cm) occurred 7 to 10 h after the applications had been made on the morning of those days. No detectable rainfall occurred during the remaining weeks of the study.

RESULTS

Table 1 shows the analysis of spray deposit that reached the cards and plates. The Bals Turbair type spinning nozzle was found capable of applying all three insecticides and produced droplets with smaller vmd's than the conventional spray system. It also increased the number of droplets recovered per unit of area. If we use the vmd as an average droplet size to determine the volume for that diameter

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[7] Volume median diameter (vmd) is the droplet diameter satisfying the requirement that half of the volume of liquid is in droplets smaller and half is in droplets larger than the vmd.

Table 1--*Results of 1976 Douglas-fir tussock moth and western spruce budworm test using two droplet sizes of three different insecticides*

Treatment	Droplet size	Vmd[1/]	Spray deposit assessment		Tussock moth percent mean mortality[2/]		Pretreatment	Budworm percent population reduction		
			Drops/cm^2	liters/ha	Pretreatment	Posttreatment	No/100 buds	3-day	7-day	14-day
Carbaryl	Large	302	15.3	0.87	3.7a	86.8a	26.7	66.0a	72.3a	85.3a
	Small	192	44.1	1.57	2.0a	98.5a	14.5	79.0a	76.9a	88.3a
Trichlorfon	Large	338	4.9	2.05	1.7a	66.3a	20.7	66.1a	68.0a	63.1a
	Small	208	33.9	2.01	2.3a	90.2b	31.3	92.2b	97.3b	96.2b
Acephate	Large	251	17.9	6.02	1.1a	80.9a	23.3	66.0a	73.1a	83.8a
	Small	200	24.5	2.94	0.4a	68.9a	27.3	79.5a	90.9a	90.8a
Control	--	--	--	--	0.7	5.0	20.8	--	20.9	29.4

[1/] Volume median diameter (vmd) is the droplet diameter satisfying the requirement that half of the volume of liquid is in droplets smaller and half is in droplets larger than the vmd.

[2/] For each pair of treatments (large droplets vs. small droplets), means followed by the same letters are not significantly different (P=0.05). Pairs compared by t test for independent means.

droplet, the small droplets of carbaryl were 26 percent of the volume of the large droplets, trichlorfon 23 percent, and acephate 50 percent.

Douglas-fir Tussock Moth

Large droplets of carbaryl gave a mean mortality of 86.8 percent and small droplets, 98.5 percent. This difference was not statistically significant (P = 0.05).

The large droplets of trichlorfon produced 66.3 percent mean mortality. When droplet size was reduced, a sixfold increase occurred in the number of droplets recovered, and the mean mortality increased to 90.2 percent, a statistically significant difference (P = 0.05).

Although the two spray systems satisfactorily atomized the oil-based trichlorfon and carbaryl, giving droplets with a fourfold difference in volume, the same systems used with the water-based acephate produced droplets with only a twofold difference in volume.

The mean mortality obtained from the bioassay of acephate was poorer than expected. Neisess et al. (1976), using a droplet of 533-µm vmd, produced a mean mortality of 97 and 98 percent with a 303-µm vmd droplet. In comparison with these two tests, both sizes of droplets produced less mortality, possibly because much of the mortality of acephate comes from initial contact of the droplets on the target insects, which our bioassay did not measure.

Western Spruce Budworm

Table 1 shows effectiveness of the two droplet sizes in reducing natural populations of the western spruce budworm. No significant difference (P = 0.05) occurred between small and large droplets for carbaryl or acephate at any of the three sample intervals. As with the tussock moth, trichlorfon produced the only statistically significant change in mortality, increasing the population reduction from 63.1 to 96.2 percent (P = 0.05).

DISCUSSION

This study demonstrated that other spray systems besides conventional hydraulic pressure nozzles are capable of applying the three candidate insecticides for control of two important defoliators of western forests. The Bals Turbair type system effectively reduced the vmd for all three materials with corresponding increase in number of droplets recovered at the sampling sites. Use of smaller droplets did not decrease the volume of the spray recovered with the oil-based carbaryl and trichlorfon. The volume of acephate recovered at ground level, however, was less for the smaller droplets than with the large droplets. Future tests with acephate using smaller droplets should take into consideration the possibility of loss by evaporation in the drier climates of the West and the use of antievaporants.

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